PROBLEMS AND FACTS ABOUT FROZEN SIBERIAN MAMMOTHS (*ELEPHAS PRIMIGENIUS*) AND THEIR IVORY[1]

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(Figs 9 to 19 Incl.)

Centuries ago rumors of the discovery in northeastern Asia of great curved tusks of ivory persistently drifted into Western Europe. Could it be true that animals apparently surpassing an elephant in size lived on the bleak tundra of northeastern Siberia? Did it not sound like a fairy story that such gigantic beasts burrowed and lived underground somewhat like our tiny moles?

Ides, the famous Dutch traveler and ambassador to China, seems to have been the earliest to gather first-hand information. On traversing northern Siberia between the years 1692 and 1695 he learned that many of the Yakuts, Tunguses, and Ostyaks steadfastly believed that these huge monsters spent their lives deep underground, moving about easily in spacious tunnels even though the earth was thoroughly frozen. Should they become particularly active the whole ground might rise above them, caving in later as they passed on. But let the "mamonts" or "ground-dwellers" come to the surface and breathe the warm air, they instantly died.[2]

This is not so strange a story when we consider that actual circumstances helped strengthen native belief. At certain places in Siberia, after the melting of the snow, plenty of bones of what later came to be called the mammoth were lying about the surface or sticking up from the ground. Here and there after the thawing and slipping of portions of steep river banks the more or less complete remains of these proboscideans had been exposed to view in the very sites where inadvertently they might have reached the fateful daylight. At other times one of these frozen giants was discovered at a point the natives imagined to be the end of the mammoth's diggings.

[1] The photographs and some of the data in this article have been kindly contributed by Dr. E. W. Pfizenmayer, Curator, Natural History Museum, Stuttgart. Formerly: Assistant, Petrograd Zoological Museum; Member of the Beresovka Mammoth Expedition; Leader of the Sangajurach Mammoth Expedition.

[2] Ides, Isbrand, 1704, 'Dreyjarige Reize naar China.' Amsterdam, p. 31.

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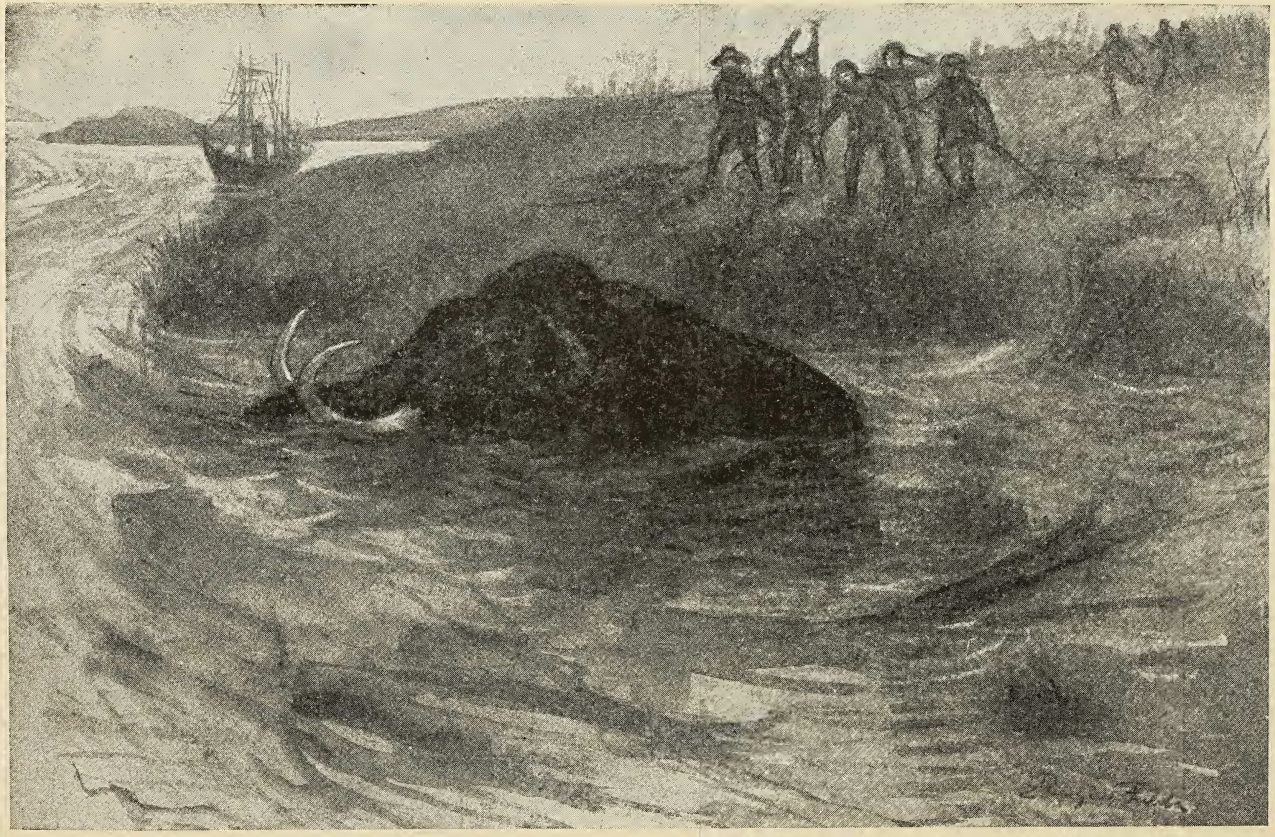

Fig. 19.—The famous frozen mammoth of the Indigirka River, Siberia. From Beukendorf's romantic story, Mrs. E. Rungius Fulda pictures the ice-mummy with hind limbs still anchored in the unthawed banks. Later, when the ground, together with the mammoth, was carried away by the force of the onrushing floods, the discoverers had a narrow escape. Reproduction from W. T. Hornaday's "Tales From Nature's Wonderland." Copyrighted by Charles Scribner's Sons.

It is with amusement we turn to the many heated, rather sprightly controversies that centered about the early finds in Europe of certain fossil bones of enormous proportions. Did they belong to giants? Certainly the few pieces available showed a more striking resemblance to those of man than to any other quadruped they could then be compared with. In Switzerland, after unearthing in 1577 some of these huge bones, the city elders of Lucerne desired to express pride in what they were pleased to consider their giant ancestor. After many enthusiastic comments they decided to figure him as bearer of the town escutcheon. More remunerative proved the resurrection of the supposedly nineteen foot tall Cimbrian king Teutobochus in 1613 near Montrigaud (Drôme), in southeastern France. The astute surgeon Mazurier arranged a traveling show, making the curious crowds pay for the pleasure of viewing the relics.

After parts of skulls, molars, and tusks had finally been obtained there was of course no question as to their belonging to some kind of elephant. Cuvier, who was the founder of the Department of Palaeontology in the Paris Museum, was the first to recognize that these gigantic bones exhumed in Western and Central Europe and the frozen remains in northeastern Siberia belonged to the same kind of animal, the extinct mammoth *Elephas primigenius*.

There was naturally a keen desire on the part of the more enlightened to recover for scientific purposes at least one of the ice-mummies, soft parts and all. As early as 1722 Peter the Great of Russia gave orders to that effect to the governor of Siberia. From time to time quantities of bones collected apparently at random were sent in. Small portions of the coveted quarry occasionally reached interested centers and kept alive the yearning for real success. But in the hope of securing more complete remains the Petrograd Academy of Science before the close of the century sent several expeditions into Siberia to have exceptionally promising finds followed up, exhumed if possible, and transported to their zoological museum.

During those early periods travel into such desolate, far-off regions was a slow and difficult process and rendered even the most hopeful of these enterprises uncertain. By the time adventurous men of science made their way over thousands of miles, the particular frozen mammoth whose quest called them into the howling wilderness had literally melted away. Exposed soft parts rapidly decayed or were destroyed by carnivores that often scattered the

bones. Floods frequently carried whole portions away, or else the oncoming winter thwarted all further attempts at recovery.

Not until 1806, however, came the really epoch-making find which solved many questions about this extinct form. A Tungusian fisherman in 1799 had located a complete, frozen mammoth on the banks of the Lena River at the threshold of the Polar Sea. Imbedded in ice, as it had been for thousands of years, its meat was still in such condition as to be eagerly devoured by polar bears, wolves, and other carnivores attracted from great distances. As time went on every warm season bared more of the body; only the natives contested the booty by securing some of the meat for their dogs through the following years of exposure. It was then that the intrepid explorer and botanist Adams happened to arrive in the neighborhood and, hearing of the famed monster, lost no time in reaching it. Most of the soft parts were gone, one limb had been carried away, and a native had sawed off both tusks and sold them for about fifty rubles. Through Adams' energy and foresight practically all remaining bones were collected. He also took to Petrograd a piece of the hide with the hair in place. It was from the still frozen side upon which the mammoth lay, and so heavy as to tax the strength of ten men to drag it along the shore. A large amount of loose, coarse hair, evidently trampled into the snow by feasting polar bears, was long enough to be considered as having formed a mane.

This mounted "Adams" mammoth, to which some of the dried parts were left adhering, served Tilesius[3] as a basis for the first figure of a complete skeleton, which by the way measures nine feet eleven inches at the shoulder and remains even to-day the largest ever recovered from Siberia. An Indian elephant from Ceylon but three inches less in height weighed 8,700 lbs. G. Cuvier soon after copied the figure of the Adams' skeleton in his famous work on fossil bones.[4] Subsequently the same illustration found its way into nearly every scientific text book and is still used in the eleventh edition of the Encyclopedia Britannica. It also was taken as a model for the setting up of practically all fossil mammoths found in Western Europe. Unfortunately it was far from satisfactory. The missing tusks of the mammoth had been replaced by com-

[3] 1815, Mém. Acad. Imp. Sci., St. Petersbourg, V, Pl. X.
[4] 1821, 'Recherches sur les Ossemens fossiles.' Nouv. ed., I, Pl. XI, opp. p 204.

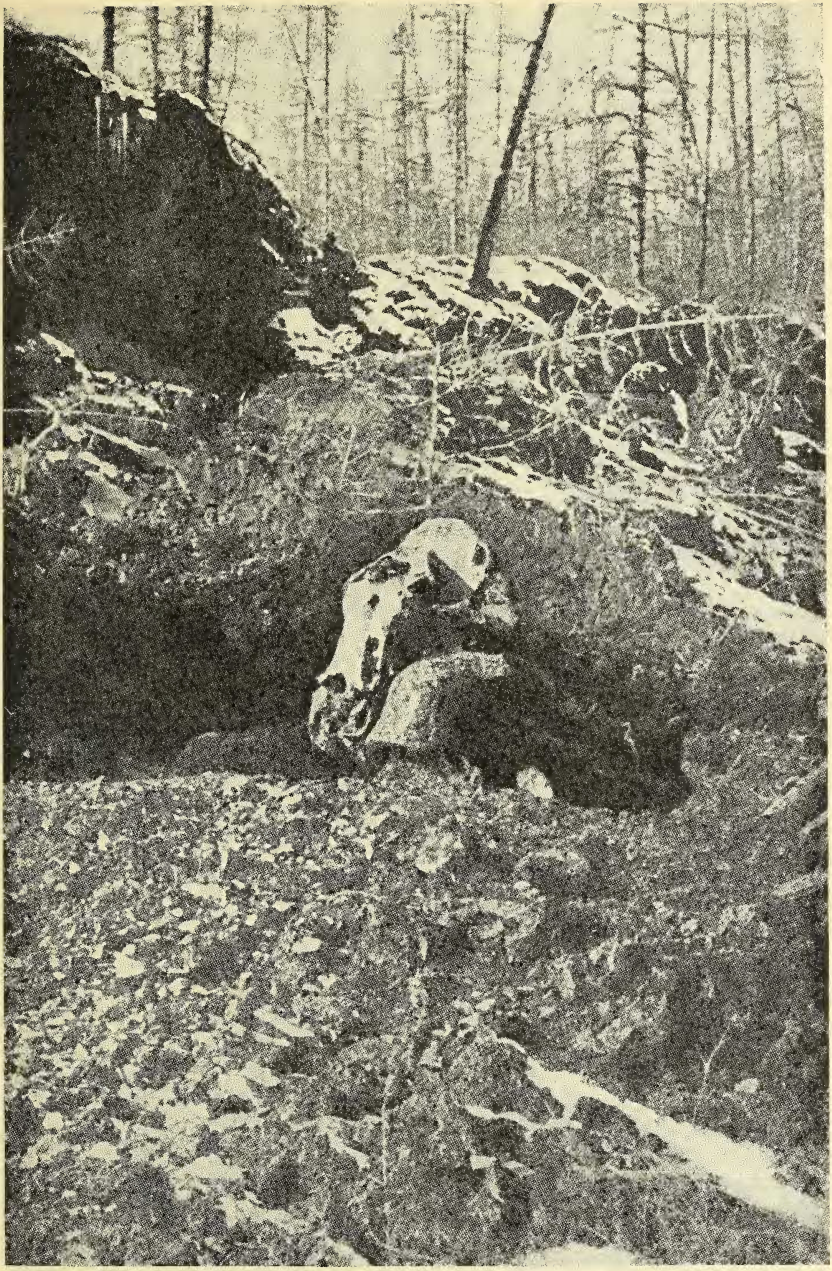

Fig. 9. The steep slope where the Beresovka frozen mammoth was discovered. Masses of thawed ground slipped and uncovered the ice-mummy that reposed here perhaps anywhere from 12,000 to 25,000 years.

Fig. 10. The Beresovka mammoth ice-mummy in process of being recovered, after the debris had been cleared away and two-thirds of the frozen body exposed to view. The skull, in the upper left corner, has been cleaned of all flesh.

bining several other pieces of ivory. According to later authorities[5] these substitutes do not correspond in either size, length, direction, or curvature with those this huge bull originally seemed to have carried.

For nearly a hundred years after Adams' mammoth skeleton had reached Petrograd no important contributions were made in this line. Attempts to secure the entire frozen remains of some of the most promising of the twenty-one finds recorded during this period resulted practically in failure. They were too widely scattered over the bleakest of ice-bound solitudes, mostly in regions beyond the Arctic circle. Here nature seemed to be intent on holding on to one of its most fanciful creations—ice-mummies.

Several Alaskan mammoths in a very much poorer and more fragmentary state were also investigated. The great credit for the rapid advance of our knowledge about frozen mammoths is due chiefly, however, to the extraordinary success of the three following expeditions: Herz-Pfizenmayer, on the Beresovka, a right tributary of the Kolyma River, Arctic Ocean drainage, Province of Jakutsk, 1901–1902; Pfizenmayer-Vollosovic, on the Sangajurach River, in the Arctic coast region opposite the New Siberia Islands, 1908; and Vollosovic, on the Liakhoff Islands, southernmost of the New Siberia Archipelago, Arctic Ocean, 1912–1913.

The Beresovka Expedition was the first to profit by the rapid transportation facilities of the then new Trans-Siberian Railway. But even from Irkutsk, the last railroad station on their route, nearly 4,500 miles had to be covered on foot, horseback, and sleigh to the Beresovka River and back. In order to continue the work of salvage in the intense cold a hut had to be built over the partially exposed remains and stoves kept burning. After tremendous hardships and in the incredibly short time of ten months all that was worth while to be had of the mammoth was transferred to Petrograd. As it reached there the middle of February, most of it was still in frozen condition. This was the first time that the almost complete skin of any fossil mammal could be mounted for exhibition. Nearly all the hair had come off but some of it was put back later. For many reasons it was found advisable to represent the mammoth in the position in which it had met its untimely death. Careful study of the exceptionally perfect skeleton of this young bull, in which but one tusk was lacking, brought out many points of

[5] Pfizenmayer, E. W., 1907, Ann. Rept. Smithsonian Inst. for 1906, Washington, p. 332.

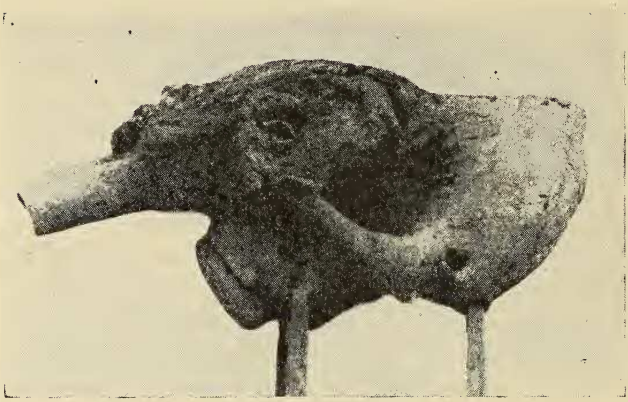

Fig. 11. Skull of the adult female Sangajurach mammoth with soft parts removed except about upper portion of face. Tusks of female elephants being easily detached, especially after a slight amount of decay, in this case they were not recovered.

interest. Modern scientific methods of collecting made possible a number of unique results in the study of various parts, such as tongue, feet, tail, stomach, muscles, hide, fat, blood, as well as its food. (Figs. 9, 10, 17, and 18.)

The Sangajurach Expedition, under the leadership of Dr. Pfizenmayer, seemed at first but little favored, for the greater part of the mammoth had been washed downstream or destroyed by Arctic foxes before the party arrived. But some lucky cause had

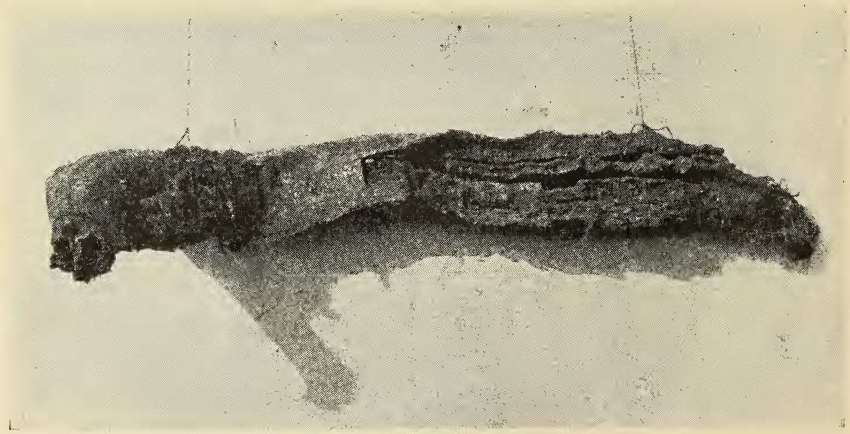

Fig. 12. Portion of the trunk of the Sangajurach mammoth, showing essentially the same structure as those of living elephants. Near the lower part, to the left, a piece of the dense hair cover.

preserved large pieces of the hide of the body and limbs with complete hair covering in place (Fig. 15). Even more fortunate was the recovery of some of the upper portions of the head and the nearly complete trunk (Figs. 11 and 12). In the case of the Beresovka ice-mummy the destruction of these particular parts as well as of the back by decay and carnivores had been a keen disappointment to all at the time.

The Vollosovic Expedition was financed by Count Stenbock-Fermor, who presented the results to the Paris Museum. This mammoth proved to be in as good condition as the Beresovka specimen and has helped to confirm and extend many of the researches made on the material from the two Russian expeditions.

Following this the late Czar issued an imperial ukase prohibiting the exportation of any mammoth or parts thereof found in Russian territory, reinforcing a former order whereby all mammoth ivory and bone had to be submitted to a committee appointed by the Petrograd Academy of Science, that might retain any parts desired.

The field observations and researches based upon the wonderfully well preserved material from the Beresovka and Sangajurach mammoths settled a number of disputed questions. Different phases of the life history of the fabulous monsters of the frozen tundra were finally cleared up, such as appearance, structure, size, habits, and even relationship. No other fossil type has left such remarkably complete data as the Siberian mammoth and to a lesser extent its partner, the woolly rhinoceros.[6]

Apart from its shaggy coat the main distinctions between the Siberian mammoth and living elephants were its much shorter, more massive body and above all its large, bulky head. The big skull had to furnish support to the enormous, spiraled tusks and weighty molars.

As in recent elephants the tusks are variable in form and much smaller in the females. Their sockets run nearly parallel. At their point of emergence from the skull the tusks first diverge—sideward, forward, and upward—and then slightly converge in the general direction of the shoulder, with tips curved inward and downward.

The tremendous size and peculiar shape of mammoth tusks have aroused many discussions. Was so excellent a student as Adams[7] right when he suggested that the hooked extremities thereof

[6] Preserved parts of a mammoth and rhinoceros were also unearthed in 1907 in pits of mineral wax in Starunia, Galicia (Poland).

[7] Adams, Andrew Leith, 1870, 'Notes of a Naturalist in the Nile Valley and Malta.' Edinburgh, p. 231.

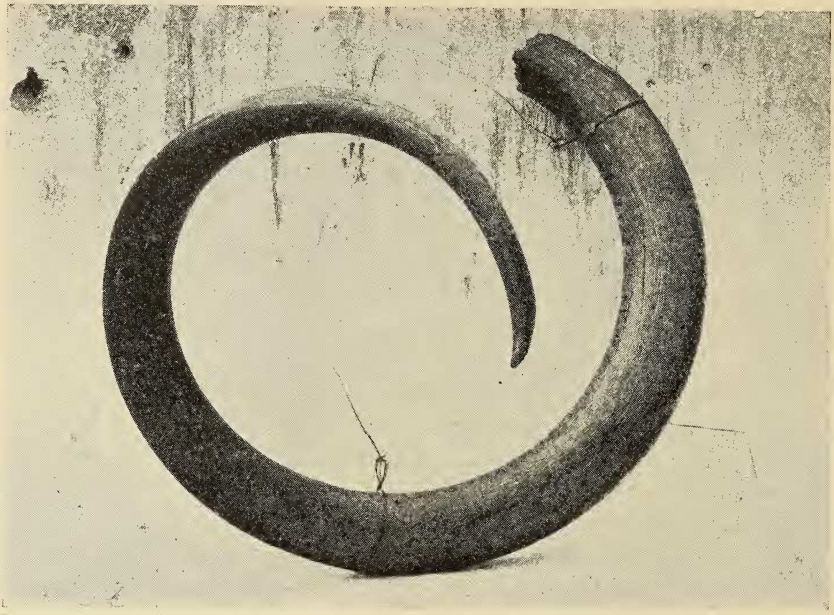

Fig. 13. An abnormally spiraled mammoth tusk. Perhaps all the part rooted in the socket, and more, is missing. From the worn tip one might presume the ivory was a bothersome burden for its bearer. Much rubbing at that point somewhat reduced its thickness.

may have been "used for pulling down and retaining branches of lofty coniferous and other trees"? Or is there reason to follow Pfizenmayer in his explanation that some apparently abnormal tusks with obliquely forward and downward directed tips served to break the crust of snow and scrape together food? Did these tusks grow to such gigantic proportions merely so the males might have a better chance to secure plenty to eat? Seldom would they care for the weaker among them. Nature would not treat in so step-motherly a fashion females and young, on whose welfare the continuity of the race depends.

In nearly all larger mammals the horns, antlers, and tusks serve essentially as weapons. In each case they are applied in the most suitable fashion. Among elephants the strongest bull of the herd enforces his right to perpetuate the race by battering every contestant with his tusks. Just one wrong blow during the fury of a contest and these ivories snap off like glass. Not rarely have large African bull elephants left one of their tusks on such battlefields.

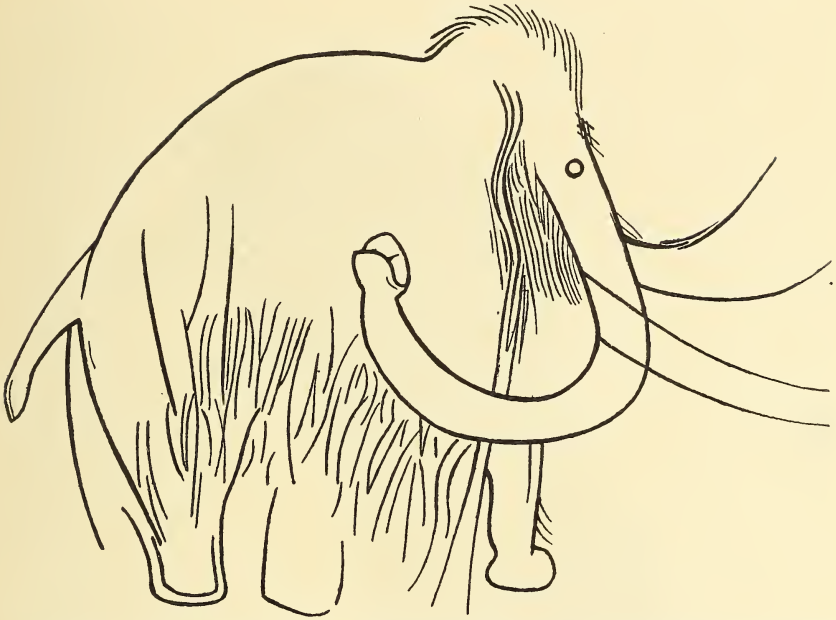

Fig. 14. Outline engraving of woolly mammoth carved by Aurignacian man of early Magdalenian times on the rocky walls of the cavern at Combarelles, Dordogne, France. After Capitan and Breuil, 1901.

Of course the extremely large, recurved tusks of mammoths, describing in many specimens fully three-quarters of a circle, undoubtedly became useless even for such a purpose. Neuville may be correct in looking upon them as more embarrassing than useful and as showing degenerating influences at work.

The largest Siberian mammoth tusk, preserved in the Petrograd Zoological Museum, measures along the outside curve thirteen feet seven and three-quarter inches, and weighs 186 lbs. The American Museum of Natural History possesses one from the Liakhoff Islands somewhat heavier, weighing 200 lbs., but only twelve feet eleven inches in length, with a greatest circumference of twenty-one inches. Lucas[8] reports one from Alaska but slightly smaller, twelve feet ten inches.

The trunk, as instanced by the Sangajurach specimen, from which only the tip was lacking, was dwarfed and weak in comparison with those of recent elephants. With all proboscideans it is an important organ, the corner-stone of touch, scent, respiration,

[8] Lucas, F. A., 1901, Ann. Rept. Smithsonian Inst. for 1899, Washington, p. 355.

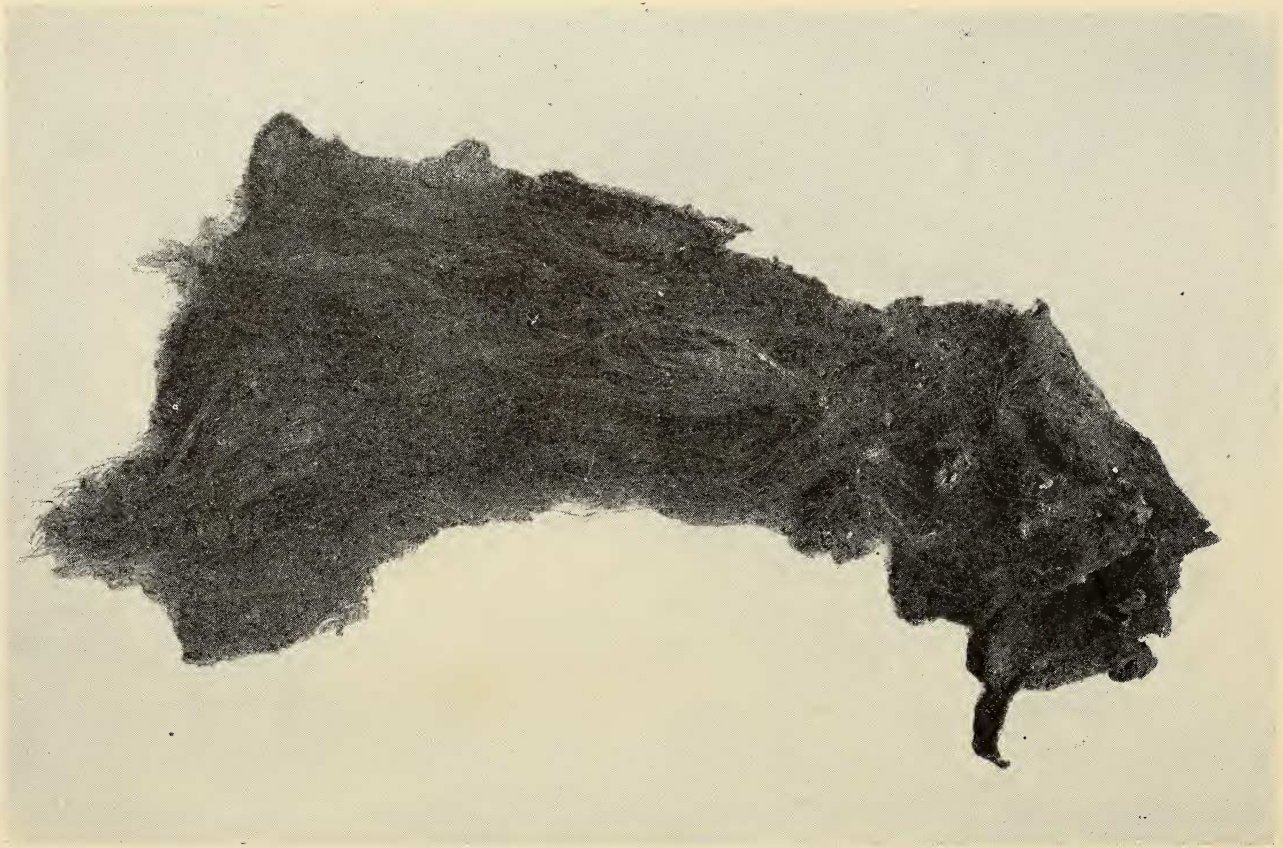

Fig. 15. A piece of frozen mammoth skin from the upper part of the thigh with most of the hair still in place. Where longest this shaggy coat measured about one foot six inches. From the Sangajurach specimen.

and constantly used to secure food and drink, as well as for defensive and offensive purposes, and during swimming, when the body is submerged.

In the mammoth, however, there is relatively little space reserved for the trunk between the huge, closely set tusks. Correspondingly small are the chief points for its support about the nasal and premaxillary bones. Evidently the principal function of this organ was to pluck grass from the forest meadows. Perhaps the Aurignacian cave man of Combarelles, Dordogne, France, whose rudely sketched outlines of the huge beast showed a two-fingered tip to the trunk, may still earn his fame as an observing naturalist.

We might conclude from the very slight development of the trunk that, influenced by the boreal climate, the mammoth's temper was of a milder sort. It seems not to have been used as an instrument of fury to devastate, break, and tear whatever may have been in its way, as is the case with the well-developed trunk of its African cousin.

The ears were considerably smaller than those of the Indian elephant, measuring in the old Adams' bull only about fifteen inches in length and six and three-quarter inches across their greatest breadth. They were densely covered with short, woolly, and longer, bristly hairs.

The bony structure of the digits of the feet showed a pronounced tendency towards reduction. Some at least of these mammoths had already lost most of what in other mammals would correspond to the thumb and big toe and were four-toed (tetradactyl) and not, like living elephants, five-toed (pentadactyl). The random numbers of toe-nails of the Paris mammoth were ascribed by Neuville[9] to degeneration. Many of these supernumerary horny growths had striking resemblance to the normal nails, others were extraordinarily long and upturned, like those recorded from some menagerie elephants.

More decisive evidence of the mammoth's truly boreal habitus was furnished by its heavy, shaggy coat. It covered the entire body, but even where longest it did not form a distinctive mane. In general appearance and arrangement it resembled that of the musk-ox. The dense, matted, woolly underfur, varying from fawn to golden brown, attained according to location up to two inches in length. A longer, coarser, yet fluffy hair had an average length on

[9] 1919, L'Anthropologie, XXIX, p. 207.

the body of a foot and a half; in color it was deep rusty brown, sometimes darker, sometimes lighter, according to peculiarities of preservation; its texture somewhat resembled the fibers in the hard outer covering of cocoanuts. Outstanding from this were the scarcer, flattened, considerably longer, black, but flexible bristles that apparently were evenly distributed over much of the body. Particularly graced with them were such parts as the chin, eyelashes, and ears. On the tip of the short tail they formed a long, fan-shaped tassel, but even there were only one mm. thick. The trunk was well covered with dense, short hair. On fore and hind limbs the longer coarse hair had an average length of one foot two inches; at the lower portions it was considerably shorter.

As usual in mammals with dense underfur the epidermis in the mammoth was extremely thin and rather smooth, in that respect quite unlike the thick, horny, rugose, sparsely bristled skin of living tropical elephants. The leathery portion, however, according to various researches, proves to have been as thick as or thicker than that of present-day proboscideans. The histological character is essentially the same in both, neither of them possessing sudoriparous or sebaceous glands. Neuville suggests that the mammoth in evolving from ancestors living in a warmer climate and adapting itself to boreal conditions greatly reduced its epidermis.

No more important factor could be cited indicating the coldness of the climate in which the mammoth lived, than the abundance of fatty tissue just below the hide. On the belly of the Beresovka male this layer was three and a half inches thick. Fat of any kind is practically absent in recent elephants, as is usual in game of tropical Africa except the hippopotamus. Its presence positively shows that at the time of death the mammoths preserved as ice-mummies were not on the verge of starvation. What better protection against the oncoming rigors of winter could be imagined than such an accumulation of fat, common in many boreal land and aquatic mammals and always in those that hibernate.

Several lucky circumstances have contributed towards our fairly satisfactory knowledge about the feeding habits and food of mammoths. From what we know about living elephants the experienced can tell from a glance at the molars that the mammoth secured its livelihood essentially by grazing and not by browsing. Its cheek-teeth present a densely crowded condition of the component transverse plates with comparatively even, yet characteris-

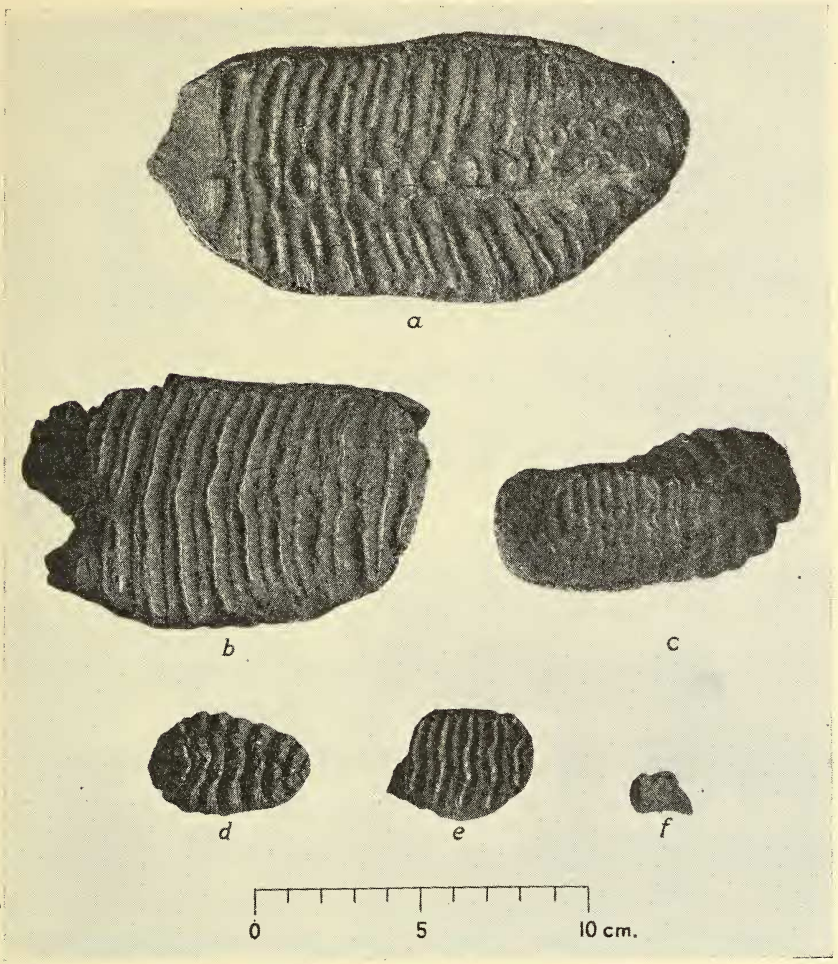

Fig. 16. Various stages in the development of upper and lower molars of the mammoth (*Elephas primigenius* Blumenbach). Anterior portion pointing toward left.

a. Third right lower molar at height of efficiency. Enclosed within the high rims of enamel of each of the numerous transverse lamellae or their parts lies the softer and lower dentine. The lamellae in turn are surrounded and united by cementum. Anteriorly this molar is worn low.

b. Second right upper molar. Some of the anterior transverse lamellae have been shed, and the remaining ones are more worn than in Fig. *a*.

c. Third right lower molar. Some of the posterior lamellae have not yet moved up from the jaw to the grinding surface.

d. Second left upper milk molar before piercing the gum. The individual transverse lamellae, still crested, have not yet been united by cementum.

e. Second left upper milk molar well worn, some of the transverse lamellae in front having been shed.

f. First left upper milk molar with a grinding surface of only 12 mm. This cheek-tooth belonged to a calf probably not more than a year old.

tically rough, crown surfaces. Their peculiarity and efficiency are greatly influenced by the singular action of food-stuffs under the pressure and friction of mastication. It is the amount of silicate, grit, and other hard materials contained in the food that causes an unequal rate of wear of the three principal substances composing these grinders. Under these circumstances the excessively hard enamel parts always remain as ridges, whereas the softer dentine and cementum form alternating depressions. The transverse plates of the cheek-teeth vary somewhat in complexity and number; from three in the first (milk molar) to as many as twenty-seven in the sixth or last molar. Osborn[10] has shown that Jefferson's mammoth (*E. jeffersoni*) of the American Pleistocene, from Indiana, may have as many as thirty in the upper molar and from twenty-four to twenty-six in the lower.

The masticating surface of the large, broadened molars* of the mammoth forms an efficacious milling apparatus for the grinding to pieces of the rather tough, but very nourishing, boreal meadow plants. A similar arrangement would not answer so well for the bulky, succulent masses of tropical vegetation on which the living Indian and African elephants subsist. The relatively compact nature of the fodder of the mammoth may have helped lessen the need for accommodating immense digestive organs and finally have led to a general reduction in size of the animal's body, back of the head, as mentioned above.

Borodin[11] was able to identify the plants found between the molars and in the stomach of the Beresovka mammoth. Above its ice mausoleum the flora of these Siberian forest meadows still showed essentially the same characteristics as thousands of years ago at the time of the victim's entombment. The average temperature may have then been responsible for a more uniform, milder climate, somewhat lacking the intense severity of present winters

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[10] Osborn, Henry Fairfield, 1922, Amer. Mus. Novitates No. 41, pp. 1–16.

[11] In: Salensky, W., 1905, Compt. Rend. Séan. VI Congrès Internat. Zool., Genève, (1904), p. 72.

*The molars, as in other elephants, after emerging from the gum gradually move forward in the jaw. As the upper portion, the grinding surface, is worn down, the originally long, anteriormost roots are absorbed or "eaten up" within their sockets by special cells, the osteoclasts. Thus only a flat, thin, center portion of the anterior part of the molars remains. As this is pushed out beyond the forward part of the socket the thin pieces of the composing plates break off easily, the worn ones being replaced by succeeding new ones from the rear. In this way the rather voluminous and heavy molars are easily accommodated in so limited a space and retain their efficiency till a relatively advanced age.

and allowing the forests to reach as far as about 74° North. The food gathered in abundance by the Beresovka mammoth just before death consisted of various kinds of grasses (*Alopecurus, Hordeum, Agrostis, Atropis,* and *Beckmannia*). Sedges were represented by two forms of *Carex*. A mint (*Thymus*), pods of a leguminous plant (*Oxytropis*), wild poppies (*Papaver*), and seeds of the northern butter daisy (*Ranunculus*) made up the list. Some pine needles and bits of wood figure as incidental occurrences.

From the above enumeration of characters it appears out of question, as formerly believed, that Indian elephants could be modified forms of the Siberian mammoth and had merely wandered southwards into the more luxuriant forests of tropical Asia, and in adapting themselves, had lost their heavy pelt and gradually changed otherwise. As shown above, the Siberian mammoth was in many ways too highly specialized to figure as an ancestor of the living Indian elephants, which must have evolved from some other form.[12]

As an argument against the boreal character of the mammoth there has been advanced the fact that in southern regions its remains were found mixed with those of such tropical types as the cave hyaena (*Crocuta crocuta spelaea*) and the cave lion (*Leo leo spelaea*), that actually had gnawed its bones. The Pleistocene European hippopotamus (*Hippopotamus major*) has been cited to the same purpose.

It is not so uncommon a feature among various groups of recent mammals to travel about in regions having relatively great differences in temperature and presenting a variety of environments. Our American bison once roamed from the plains of northern Mexico to the woodlands of Canada beyond Slave Lake. Another example is our puma, of which Theodore Roosevelt writes in his admirable account: "It is found from the cold, desolate plains of Patagonia to north of the Canadian line, and lives alike among the snow-clad peaks of the Andes and in the steaming forests of the Amazon." Another instance is offered by a race of white-footed mice (*Peromyscus*), whose footprints Dr. E. W. Nelson records having seen at 15,000 to 16,000 feet above sea-level on the volcanic ashes of Mt. Orizaba, Mexico. It thus furnishes the altitude record for North American mammals.

In Africa the browsing elephant (*Loxodonta africana*), with

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[12] Osborn, Henry Fairfield, 1910, 'The Age of Mammals,' New York, p. 419.

its preferred haunts in denser wooded parklands, roams also over trackless swamps and enters arid desert stretches. The grazing buffalo (*Syncerus caffer radcliffei*) leaves the plains and invades forests, making itself at home even at 10,000 feet. Both on Mounts Kenya and Kilimanjaro records of the two visiting snow-fields and glaciers are at hand. More surprising still are the giraffe (*Giraffa camelopardalis tippelskirchi*), exploring the mountain forests of Kilimanjaro, and the eland (*Taurotragus oryx pattersonianus*), going even beyond to the mountain meadows. The lion in East Africa ascends from the lowlands to above 7,500 feet as in the Rift Valley and within the range of the mountain gorilla (*Gorilla beringeri*) on Mount Sabinyo,[13] reaching altitudes where the temperature during the night may drop below the freezing point. The lion has been bred with success freely exposed to the wintry rigor of the climate of Dublin. Leopard (*Panthera pardus suahelica*) and hyaena (*Crocuta crocuta germinans*), also typical animals of the lowland, go to over 9,000 feet on Mount Kenya. There, up to 15,000 feet, near the border of eternal snow, hyraxes (*Procavia mackinderi mackinderi*) too occur, differentiated only subspecifically from the lowland form. Colobus monkeys (*Colobus abyssinicus kikuyuensis*) are none the worse for icy-cold nights at 10,000 feet, though equally at home in the hot valleys far below. River-horses (*Hippopotamus amphibius*) even in captivity seem not to be so susceptible to cold as generally believed. In the zoological garden in London at least they were known to take their tubs in frosty weather.

Africa, with its very restricted mountain areas, gives no fair basis as to what happens in Asia with its more extensive ranges and mountain plateaus, or to what might have taken place in this respect during the glacial periods of the Pleistocene. Even among recent mammals the list could be increased considerably. One need merely mention the hardy, long-haired Manchurian tiger and the well-furred snow-leopard with firmly established haunts in colder climes though their closest relatives inhabit the tropics. The camel (*Camelus bactrianus*) and the yak (*Poephagus grunniens*), that survive the icy blasts of the Tibetan plateaus, show not the slightest effect in their welfare or reduction in breeding on descending into more temperate zones.

Certain it is that many of the high lands of the Pleistocene presented a wide, open expanse with an abundance of excellent

[13] Philipps, J. E. T., 1923, Geogr. Journ. London, LXI, p. 247.

pasturage, as indicated by the large herds of gregarious mammals. There should be no surprise that some of the southern carnivores, like the lion, hyaena, and others, followed up such promising prey. Perhaps the borders of rivers in the summer offered also an abundance of choice fodder to the hippopotamus. All points considered, there is no reason why the hairy mammoth should not have wandered south. Its rambles may even have been undertaken during the colder season.

Being great nomads, like most of their relatives, the mammoths unquestionably wandered back and forth through most of the northern countries of Europe, Asia, and America. During the moist, cool climate of the third glaciation they made their first appearance in Western Europe, going as far west as the British Isles, at that time a peninsula, with the North Sea firm land; and even to Denmark and Scandinavia, where it was probably the remaining glaciers that stopped them at 62° North in Norway at Saejervaskter in Vaage; attaining, however, to 65° 30′ North in several places in Finland bordering the extreme north of the Gulf of Bothnia.[14] They also went southward to northern Spain and to Italy within the neighborhood of Rome. From northern Siberia they passed over to Alaska and America by way of Bering Strait or the Aleutian Islands before the separation of these continents took place, thence to California and across to North Carolina.[15] On the American continent their evolution progressed into still more gigantic forms as they reached evidently more inviting regions farther south.

Encouraged by slight fluctuations of temperature while glaciers were slowly advancing and retreating during the Pleistocene period the mammoths, like other mammals, shifted according to seasonal changes, either north or south, just as some of the African elephants nowadays accommodate themselves to dry and wet periods by traveling from the lower plateaus into the mountain forests and to escape from the annual grass-fires of the savanna into the safety of extensive swamp-lands. At the close of the glacial periods their haunts must have vitally changed. The mammoths apparently were not able to follow any more in the wake of the retreating ice and must have encountered conditions that sealed their fate.

Most interesting is the evidence of what the gigantic beasts

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[14] Holst, Nils Olaf, 1913, L'Anthropologie, XXIV, pp. 363–364.

[15] Matthew, W. D., 1915, 'Mammoths and Mastodons,' Amer. Mus. Nat. Hist., No. 43, Guide Leaflet Series, p. 6.

must have meant to the cave-dweller of Europe. The Crô-Magnon men of France[16] were the first to leave for posterity authentic outlines of these monsters they had hunted. One of the finest examples is the sketch of a huge, shaggy tusker cut into a slab of mammoth ivory found in "La Madeleine" cave. This and other equally characteristic pictures, such as a curious little figure of the mammoth found at Predmost, furnish proof of the absorbing interest early Paleolithic man evinced in glorifying the enormous beast his heroes succeeded in overpowering. These early artists evidently wished to commemorate the bearer of so bountiful a supply of meat. They undoubtedly used parts of it as talismans, as in the case of a child's necklace of mammoth ivory beads found at Predmost.

In all probability the extinction of the mammoths was a gradual process and may have lasted hundreds of years or more. No single cataclysm, as Howorth[17] believed, could have been widespread enough to account for their abundant, mostly scattered remains throughout the Holarctic regions preserved, as they are, in such different ways. Besides innumerable traces in northeastern Siberia, the neighboring Polar Sea, and the American continent, great accumulations of their fossil bones occur also in certain places in Europe. Predmost in Moravia, where some eight hundred or nine hundred individuals were counted, is particularly famous, but the mammoth deposits near Cannstadt in Würtemberg and Hofstade in Belgium illustrate similar instances.

According to all authentic reports the mammoths preserved as ice-mummies, and found under various conditions of entombment, perished singly. Some of them were in prime condition, as young and fat individuals prove, and had plenty of fodder in their stomachs. These facts strongly favor the view that they met with accident, as instanced by the Beresovka and other finds. For this reason they have hardly any direct bearing on the real causes of extinction of their race that is to be set at a much later period. In a way they might be compared with the frozen body and a skeleton of the African buffalo found by Ross[18] and Mackinder, respectively, at about 14,000 feet on the glaciers of Mount Kenya. Wandering away from one of the many herds in the plains these rovers had perished on their unknown but curious excursion.

[16] Osborn, Henry Fairfield, 1921, 'Men of the Old Stone Age,' 3rd ed., New York, pp. 397–398, figs. 197–199.

[17] Howorth, Henry H., 1887, 'The Mammoth and the Flood,' London, p. xviii.

[18] Ross, W. McGregor, 1911, Journ. East Africa and Uganda Nat. Hist. Soc., II, p. 63.

It is significant that only the most gigantic mammals of this decidedly gregarious Pleistocene fauna have been transmitted to posterity in frozen condition. Their tremendous weight and relative clumsiness seem to have played an important rôle. Did they slip and fall, or were they precipitated to depths where cold would preserve them? Or were some of their bewildered troops devoid of the necessary agility and grit to extricate themselves from overwhelming storm and deep snowdrifts? Or did furious gales and blizzards cover them alive with icicles that quickly grew to encasing blocks of ice? As regards greater catastrophies, subsiding land-masses may have brought their doom, or inundations engulfed them. A few may have found their final resting places in swamps and bogs. Considering the various finds, certainly some and perhaps all of the contingencies enumerated contributed their share to the final extinction of the mammoth.

Every spring as a result of the setting in of warmer weather the important Siberian rivers move enormous masses of ice towards the Polar Sea. The clearing away of these obstructions is watched with intense excitement by the inhabitants of these ice-bound regions. A few months of river navigation means new freedom of traffic. They again can rove far and wide. It is then that hungry dogs may lead their masters to the masses of strongly smelling meat of the "mamonto" that has incidentally been uncovered along the thawing coves and banks.

Mighty are the struggles oncoming spring leads against the wintry forces. For a while great portions of these streams are dammed up by mountains of constantly shifting ice-floes. When these finally break through, parts of a new channel are often enough quickly ploughed up. After the generally sudden subsidence of these temporary floods, the old, abandoned stream bed freezes over again, imprisoning huge blocks of ice, debris, and all. Some of the water for a while held below the icy cover drains off and here and there large scattered pits are left between the chaotic masses. After years have leveled out these sites, ponderous beasts like mammoths wandering over such treacherous places might easily break through, be instantly killed, or become hopelessly mired. Later on erosive material piled over all may have formed the basis for the surface soil that practically furnished permanent protection. A few frozen bodies found in what was considered alluvial soil, mixed with pieces of ice, in a position as if ready to walk off, may have perished in this manner.

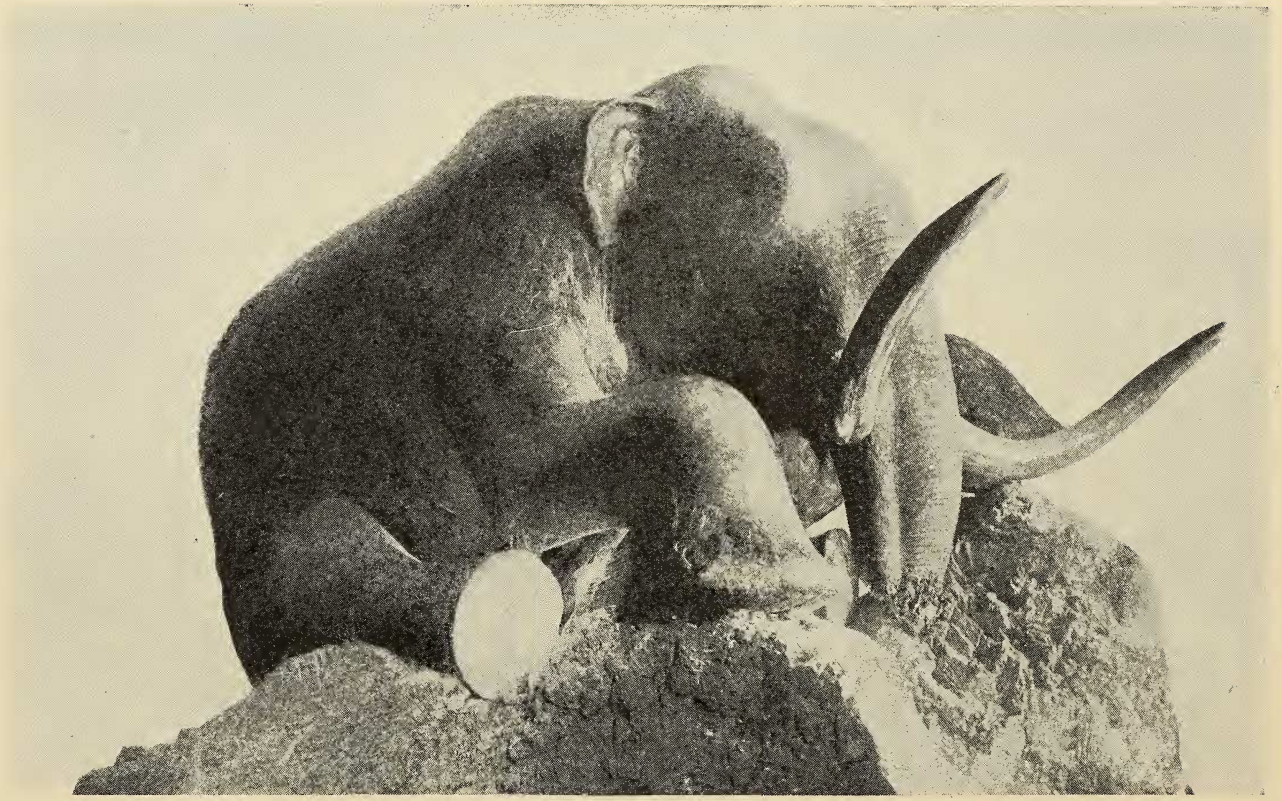

Fig. 17. The mounted mammoth unearthed in 1901 as an ice-mummy on the banks of the Beresovka River, northeastern Siberia, as it appears on exhibition in the Zoological Museum in Petrograd. The animal has been partly restored. Much of the real skin could be used in the mounting. Some of the hair has been replaced.

The cramped position, broken bones, large amount of clotted blood in the body cavity, as observed in the Beresovka mammoth, point, as Salensky shows, towards instantaneous death by accident. The victim did not even have time to throw out or swallow the quantities of fodder between its molars and in process of mastication. Salensky gives a cause for such a tragedy. During extremely rigorous winters the formation of wide fissures in the ground is not rare in northeastern Siberia. With the oncoming warmer season these clefts rapidly fill with water which may cause extensive subterranean washouts. Later some colder spells may cover such basins with a sheet of ice, below which the percolation of the remaining water continues in other directions, thus giving rise to what really amounts to an underground cave. Subsequent strengthening of the surface ice and final covering with humus, until level again, would form a sufficiently strong cover for everything except the weight of so colossal a beast as the mammoth or rhinoceros. Late in summer such places might be specially weakened and the unfortunate animal crashing through into the cavities would be instantly imbedded in the masses of ice and frozen debris loosened by the accident. Severe storms and periods of intensive freezing that usher in winter would soon remove all traces of the entombed. For thousands of years the victim might never be moved, except through the infinitely slow processes of floods and similar erosive actions.

Without question all those mammoths discovered frozen in practically fresh condition were at the very moment of their destruction surrounded by a temperature that completely excluded decomposition. The perpetually frozen ground of northern Siberia acted much like a modern refrigerator. For periods variously estimated at anywhere from 12,000 to 25,000 years, such ice-mummies may have reposed far below the protecting mantle of tundra vegetation. Here, as in the vast expanses of the "taiga," the swampy Siberian forests, they were, so to speak, permanently protected, the ground being frozen generally at three feet below the surface even during the hottest of summers. That great numbers of these and other mammals perished without being preserved in such perfect fashion is sure. In some places the earth and the shores of certain islands along the Polar Sea were literally crammed with their bones. The solid clay of higher sites inland preserved them pretty well, but elsewhere climatic conditions

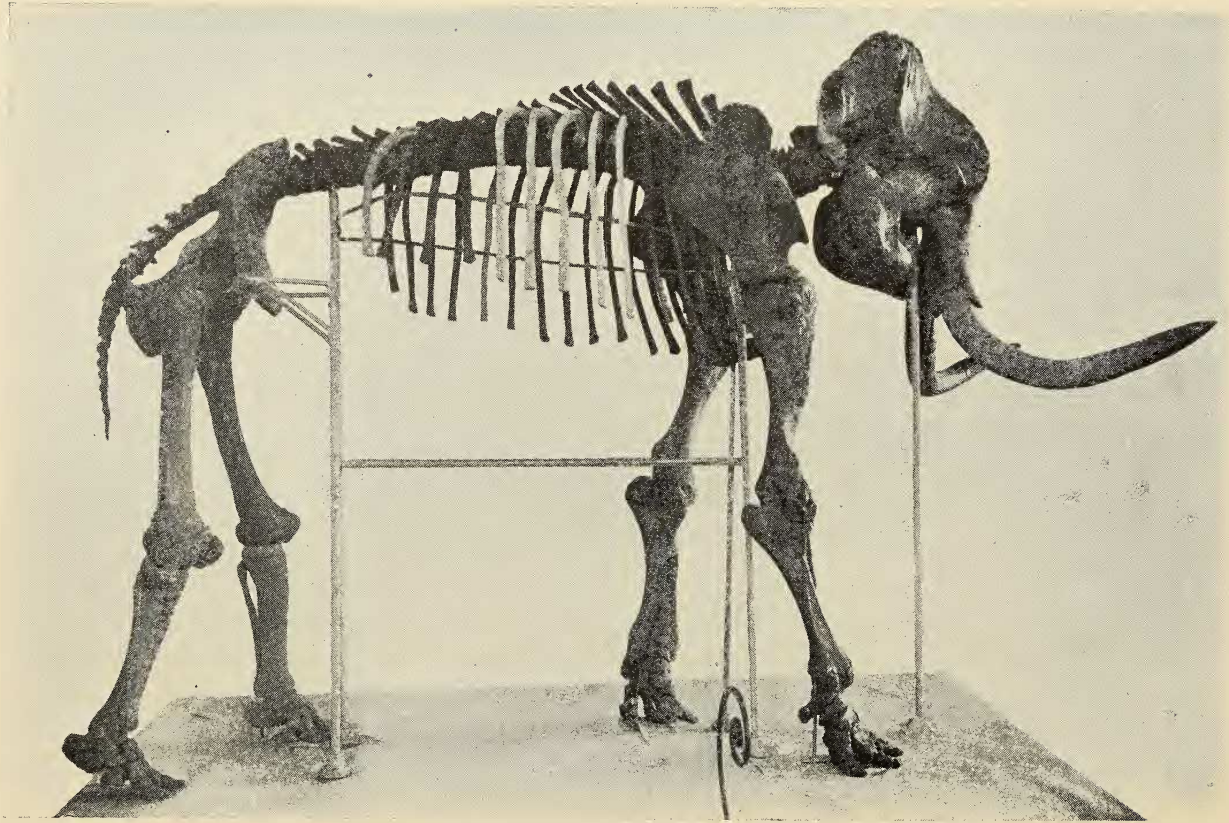

Fig. 18. The Beresovka mammoth skeleton as mounted in the Petrograd Museum. One tusk and several ribs had to be replaced. To the top of the head the animal's height is given as ten feet nine inches.

fostered the more rapid decay of others, or without doubt there would be many more.

Mammoth tusks have for many reasons aroused considerable interest. To the scientist they are the permanently growing second pair of upper incisors, composed mainly of a solid but peculiar dentine, the "ivory" of commerce. To the poor Siberian hunter, with his pick and ax ready to chop into pieces whatever tusks he can discover on his migrations in the wilderness, they are "white gold." To the Chinese artist the delicate, fine texture and peculiar pallor of the easily carved substance brings new incentive for his varied talents.

Strongest is the claim of the superstitious. Small parts of mammoth ivory have meant to him the chance of his life. They have served even as relics of Christian saints. We are told that devout prayers addressed to them have given earnestly hoped for succor and success. Heathen with still stronger beliefs deeply implanted in their hearts as regards the occult powers of this marvelous substance have had their satisfaction too. Equally many-sided were the supposed medicinal virtues of mere scrapings. The Chinese have been more beguiled by them than by their "dragon bones." And western Europe did not free itself so very long ago from faith in such wonder cures. With their application, hemorrhages, ulcers, broken bones, epilepsy, fevers, plague, and cholera[19] would all vanish, according to the fancy of many. For that very reason they furnished princely revenues. As many as sixty tusks from the fossil mammoth deposits at Cannstadt were sent to the pharmacy of the Court, and became the precious powder of the "Licorne."

Gross credulity has been carried even into other channels. What of the warrior whose sword hilt, carved of mammoth ivory, is worth more to him than one wrought of gold or silver?

In the matter of art Siberia itself has made little use of its great supply of ivory. Only a few figurines, animals, characteristic scenes of the native land, often in heavy relief or bold freedom, combs, vases, and boxes, are made in certain centers. Export of the crude tusks after all has been the mainspring of their efforts.

A great impulse to the exploitation of Siberian mammoth ivory along the edge of the Polar Sea, its cliffs, and islands near the mouth

[19] Kunz, George F., 1916, 'Ivory and the Elephant,' p. 239.

of the Lena, was given when Catherine II, Empress of Russia, took a personal interest in the matter. In October 1771 she wrote to Voltaire[20]: "But what proves, I think, that the world is a little older than our nurses tell us are the finds of bones of elephants long ago extinct in these regions and imbedded several fathoms below the surface of the ground in northern Siberia. Scientists . . . have said that it is fossil ivory, but, how is it possible? fossils do not grow in the form of very complete elephants."

Some time before, she had given orders to investigate the archipelago later known as the "New Siberia Islands," whose highest point attains 1,200 feet. The southern two, low, and completely uninhabited Liakhoff Islands were named in honor of the fur merchant who, following the tracks of an enormous herd of reindeer coming from the north, discovered what later proved to be inexhaustible mines of mammoth ivory. The Czarina also had conferred on Liakhoff the exclusive right to hunt and to collect ivory on them.

Many huge tusks were partly sticking out of the sand and others, together with bones, were constantly swept up on the shores by the waves. To what depth do these marvelous deposits cover the sea-bottom no one seems to know. Did these vast stores of wealth come from further inland, and were they carried out to sea with the crushing masses of ice in the spring? Here and there a frozen mammoth might have been moved thus along when whole sections of the partly thawed up river banks were undermined or torn out. Or did countless numbers of these huge beasts make their last desperate stand in these regions before the land was swallowed up by the sea?

Evidence for subsidence of land masses is more certain, as apparently much of this expanse once formed part of the Asiatic mainland. On some of these islands Silurian coral and Devonian limestone, volcanic rocks, indicate that uplifts, as might be expected, had a part in the present physiographic configuration. On the northernmost, Hedenström found Tertiary strata with fossil bituminous tree trunks in horizontal and upright positions, over 200 feet above sea-level. Other rich deposits of the same age with their interesting fauna and flora indicate a climate once very much warmer. But some of the lower islands off the coast show a few peculiar granite boulders and are covered with a deep mantle of drift formed chiefly

[20] Boule, M., 1917, L'Anthropologie, XXVIII, p. 187.

of sand, and buried ice in separate layers and incongruous blocks. These deposits were particularly rich in ivory tusks and masses of mammoth bones. Associated with them were the remains of other of the northern Pleistocene mammals, such as the woolly rhinoceros (*Coelodonta antiquitatis*), Siberian bison (*Bison priscus*), wild horse (*Equus caballus fossilis*), moose (*Alces latifrons*), reindeer (*Rangifer tarandus*), and musk-ox (*Ovibos fossilis*).

Unquestionably the mammoth was boreal in habits and most abundant in the colder regions. In northern Siberia, it flourished in all the territories between the Ural Mountains, Obi, Yenisei, Lena, Indigirka, and Kolyma, and particularly in the adjacent islands of the Polar Sea. These, therefore, with their fabulous stores of ivory, are the greatest graveyard of mammoths known. Von Wrangell described some parts of this region as containing hecatombs of such remains before they were ransacked by those in search of the valuable tusks. Should we wonder that for over a hundred years organized ivory collecting flourished without any apparent diminution of the supply?

The rigor of the climate imposed by far the greatest drawback to this greedy quest. At Liakhoff Island the open season lasts really but a few months. Bunge[21] in 1882–1884 records 90° F. below freezing point in winter, with snow falling half through July. But even under such trying circumstances enormous quantities of ivory have been removed. In 1821 one trader alone sent off 20,000 lbs. Middendorff in 1841 estimated the annual output for the preceding twenty years as at least a hundred pairs of tusks. In 1881 Nordenskiöld,[22] basing his opinion partly upon the amounts still shipped, considered this figure as rather too low than too high. He arrived at the conclusion that since the conquest of Siberia select tusks from 20,000 mammoths had probably reached the markets of the world.

From Westendarp we know that the fairly well stabilized imports to Europe of fossil ivory in 1872—with London then the chief market—amounted to 1,635 mammoth tusks or about 245,250 lbs., granting an average weight of 150 lbs. apiece. The proportion of well preserved ivory among such lots is surprisingly small—only 14 per cent; and a slightly larger amount, 15 per cent, is absolutely

[21] Bunge, 1893, Congrès Internat. Zool., Moscou, Session II, (1892), pt. 2, p. 282.

[22] Nordenskiöld, A. E., 1881, 'The Voyage of the Vega around Asia and Europe,' London, I, p. 404, footnote.

useless. But even the really "bad," amounting to 54 per cent, and the "still workable," 17 per cent, when treated properly and fashioned into the plainer objects passed in the trade.

For the most part these could not have been tusks of mammoths entombed in ice, the ivory of which compares well with that of recently killed elephants, but evidently had been subject to various disintegrating influences. So great was the demand for this remunerative article that in Europe mammoth tusks of far inferior quality to the Siberian product were formerly dredged in quantities from the Doggerbank by the North Sea trawlers.

In rare cases mammoth ivory is slowly impregnated with certain metallic salts and then known as odontolite or blue ivory. Used for jewelry it is highly prized for the delicate, yet vivid, blue, turquoise-like luster. The Eskimos of Alaska, according to Gilmore, are fond of a blue dye they secure from the phosphate of lime (vivianite) formed by the decomposition of mammoth tusks.

Many hundreds of thousands of these enormous tusks must have completely decayed. What great herds of shaggy mammoths may have roamed during Pleistocene times in the proximity of the circumpolar area can be deduced from Darwin's computations[23] about the possible increase of the recent elephant, considered the slowest breeder of known animals. If, at a minimum rate of natural increase, between the ages of thirty and ninety years, only three pairs of young be raised, he comes to the conclusion that "at the end of the fifth century there would be alive fifteen million elephants, descended from the first pair."

The Pleistocene mammoths during several hundred thousands of years had totally adapted themselves to a life in a monotonous, frigid zone. Uniformity indeed is the hall-mark of boreal regions as much as diversity is that of the tropics. During so long a period they gradually became highly specialized, long-lived monsters. Being excessively slow breeders they entered a stage where further evolution or even slight adaptive changes were reduced to a minimum. This meant the death warrant of their race. Perhaps in the boreal climate the balance of endocrine functions had long before been disturbed so that undesirable specialization went on unchecked and possibilities of forming varieties of greater vitality were practically eliminated. But whatever the causes of their final

[23] Darwin, Charles, 1860, 'On the Origin of Species,' 2nd ed., p. 63.

extinction, here, at least, nature has preserved from the enormous numbers of these shaggy monsters a few victims of individual accidents as ice-mummies. They have now become a unique source of information. Still others rest in frozen Siberian ground waiting to disclose more secrets of bygone ages.